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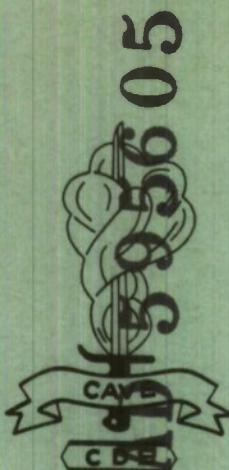
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**PROTECTION OF THE CREW OF ARMOURED  
FIGHTING VEHICLES [C]**

by

P.L. Evans

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PROTECTION OF THE CREW OF  
ARMOURED FIGHTING VEHICLES

BY

P. L. EVANS

SUMMARY

1. The tactical use of NBC agents in operations involving armoured fighting vehicles (AFV's) is aimed at reducing combat efficiency either by inflicting casualties or by causing defensive measures to be adopted. These defensive measures include the adoption of the two types of protective posture, i.e. individual protection and collective protection, either separately or in combination. To find the protective system most suited to the needs of an AFV, or type of AFV, an assessment has to be made of the effects of protection on combat efficiency.
2. The aim of this paper is to develop a rationale of the relationships between NBC protection and combat efficiency. This will take the following form:-

a. an analysis of factors contributing to the combat efficiency of the crew members of AFV's,

b. identification of those factors affected by NBC protection,

c. determination of the principal roles of three types of AFV, these being main battle tank (MBT) and two types of mechanised infantry combat vehicle (MICV), viz,

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reconnaissance vehicle (RV) and armoured personnel carrier (APC). The APC will be represented by the FV432 both in the "straight" APC role, and also with a turret mounted weapon. The importance of factors sensitive to NBC protection with respect to these principal roles will be assessed.

3. Combat efficiency has been defined in terms of measurable quantities involving the crew activities and the attributes of AFV's. A cause and effect structure has been developed showing the way in which the attributes of AFV's are used to attain combat efficiency. The cause and effect structure provides a basis for the understanding of combat efficiency, and an analysis of it allows parts of the structure that would be affected by NBC protection, i.e. those parts where an intimate crew interaction is involved, to be identified and isolated. The effects of NBC protection on combat efficiency may then be studied using the reduced diagram so obtained.

4. The relative importance of the attributes that would be affected by NBC protection has been estimated for each type of AFV. The main tasks for each of the three types have been classified and ranked according to subjective estimates of importance; these were obtained from questionnaires completed by representative users. The relative importance of the attributes for each type of vehicle for the execution of each of these classes of task has also been estimated similarly. These estimates enable the overall relative importance of the attributes to be established for each type of AFV.

5. The establishment of scales of importance for the vehicular attributes has enabled appropriate aspects of the operation of AFV's to be studied in suitably designed field trials.

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PROTECTION OF THE CREW OF  
ARMOURED FIGHTING VEHICLES

BY

P.L. EVANS

INTRODUCTION

Protection Against NBC Agents

1. The tactical use of NBC Agents (ref 1) in operations involving armoured fighting vehicles (AFV's) is aimed at reducing combat efficiency either by inflicting casualties or by causing defensive measures to be adopted (ref 2). These defensive measures include the adoption of the two types of protective posture, i.e. individual protection and collective protection, either separately or in combination, and the selection of the most appropriate system for each type of AFV is a major problem requiring solution at the earliest date.
2. Present individual protection requires respirator, over-garment (NBC Suit), overboots and gloves, and this ensemble provides the maximum protection available at present against the BC threat, and the residual nuclear threat. Additional protection against nuclear attack may be obtained from the vehicle. Wearing the full NBC ensemble continuously, however, may impose undue strain, and to avoid fatigue relief is needed from this burden, possibly in the form of rest in a secure collective protection environment.
3. Collective protection may be provided by the AFV, this being built in in the form of a vehicular filtration unit and, provided that the collective system remains operational and the vehicle interior remains uncontaminated, there is no need for the crew members to use individual respirators within the vehicle.

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Personnel will have to revert to individual protection if this system is broken or if they have to dismount.

4. To find the NBC protective system most suited to the needs of an AFV, or type of AFV, an assessment must be made in terms of:-

- a. technical performance
- b. the effects on combat efficiency
- c. cost effectiveness including maintenance and logistics.

Assessments of a. have already been made and assessments of b. are now required as a precursor to c. The data on combat efficiency is also required to enable the capabilities of troops under NBC and environmental stress to be assessed.

5. The effects of NBC protection on combat efficiency could be studied in a number of ways, including, for example, computer simulation techniques and direct measurements in suitably designed field trials. It was decided to adopt the latter simpler approach and this paper is concerned with the development of a rationale of the relationships between NBC protection and combat efficiency as a preliminary to the planning of suitable trials.

AIM

6. The aim of this paper is to develop a rationale of the relationships between NBC protection and combat efficiency.

This will take the following form:-

- a. an analysis of factors contributing to the combat efficiency of the crew members of AFV's,
- b. identification of those factors affected by NBC protection,
- c. determination of the principal roles\* of three types of AFV and an assessment of the importance of factors

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\* Role. The part played by; AFV's function, what it is expected or has undertaken to do.

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sensitive to NBC protection with respect to these principal roles. The three types of AFV will be main battle tank (MBT) and two types of mechanized infantry combat vehicle (MICV), viz., reconnaissance vehicle (RV) and armoured personnel carrier (APC).

7. This preliminary work will be followed by field trials with the following objectives:-

a. direct measurement of combat efficiencies, or of differences in combat efficiency, of crews adopting the alternative NBC protective postures and operating their vehicles in their principal roles as determined in 6 c. above,

b. analysis of standard drills of crew members operating as in 7 a., to provide data for network diagrams describing their activities, and to determine the critical paths in these networks. (It is anticipated that the critical paths may vary with the NBC posture adopted),

c. comparison of the results to draw conclusions on combat efficiency, and to advise on the most suitable protective systems.

ASSUMPTIONS AND LIMITATIONS

8.a. Three types of AFV will be examined, viz., MBT, RV, and APC (see para 6).

The initial appraisal of combat efficiency will be in terms of AFV's in general; the subsequent identification of factors affected by NBC protection will be drawn from this appraisal (see 6 a. and 6 b.). In determining the principal roles of AFV's the three types of AFV will be considered separately (see 6 c.).

b. The subsequent field trials will be performed with the following vehicles representing their type:-

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TABLE 1. Possible Restrictions on Crew Skills Due to NBC Protection

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Basic Skill/ Means	Facility	Vehicle Equipment	Protection Afforded By			
			Close- down	Over- boots	CB Suit	Gloves
<u>Auditory,</u> <u>oral</u> <u>sound</u>	<u>Outside</u> ; telephone, WT	Microphones			X	X
	<u>Inside</u> ; IC	Microphones			X	X
	Direct				X	X
<u>Visual</u> <u>light</u>	Field of view, intensity, direction	Optics, peri- scopes, bino- culars, sights, gauges, lights			X	X
					X	X
<u>Tactile</u> <u>touch and</u> <u>manipulation</u>	Sensitivity, grip, flexibility, access	Instruments and general equipment, verniers			X	X
					X	X
<u>Translative</u> <u>mobility,</u> <u>agility</u>	Foothold, speed, access, exit and entry	Foot controls, platforms and surfaces, hatches			X	X
<u>Executive</u> <u>work</u>	Physical energy, strength	Various			X	X
<u>Cognitive</u> <u>information</u> , <u>decision</u>	Various senses, includes judgement, awareness and responsiveness	Communications equipment, various other equipments			X	X

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<u>Type of AFV</u>	<u>AFV</u>
MBT	Chieftain
RV	Scorpion, CVR(T)
APC (i)	FV432 in "straight" APC role, or Spartan.
(ii)	FV432 with turret mounted weapon

c. In the collective protection posture it is assumed that the crew will be wearing NBC suits and overboots, that the full air purification system will be operating, and that the AFV will be closed down.

d. In the individual protection posture it is assumed that the crew will be wearing the full NBC ensemble and will be making use of the ducted air supply to reduce breathing resistance, and that the AFV will be closed down.

THEORETICAL DEVELOPMENT

Efficiencies of Personnel

9. An AFV must be equipped to meet the demands of a number of operational tasks (ref 3), and to carry out these tasks effectively the crew must be able to use their skills efficiently. Various types and degree of skill are required to operate the equipments provided, and also an adequate number of crew are required if their capabilities are not to be strained. Table 1 shows how use of the skills of the crew may be hampered by the use of NBC protection. The effects of restrictions may be physical or, especially in the longer term, in the form of physiological and psychological stresses. The restrictions on the crew skills may be broken down into three parts, that due to

- a. NBC suit and overboots, which will always be worn,
- b. enforced closedown, (see assumptions),
- c. wearing of respirator and gloves, in the individual protection posture.

These restrictions may operate independently or synergistically to affect specific tasks or skills; they may thus produce two

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overall effects which will be described herein as (i) skill inhibition and (ii) accelerated fatigue. These two effects together cause the loss in combat efficiency described as combat degradation (ref 4).

Crew Workload

10. Studies on the activities of AFV crews during a conventional battlefield day show that they spend their time as follows (ref 5):-

- a. halted while the crew attend to personal needs,
- b. halted while the crew service and maintain their vehicle,
- c. moving, either repositioning or searching,
- d. in contact with the enemy.

The crew must remain protected for the entire time spent in an NBC environment. The form of protection best suited for these activity time periods will depend on the following considerations:-

- i. the need for maximum rest and relaxation during (a) and (b),
- ii. the need for maximum combat efficiency during (c) and (d),
- iii. miscellaneous factors including the need for silence (filtration units require the operation of generator motors), fuel and power reserves, filter life, and, when in activities (c) and (d), problems relating to vehicle evacuation (ref 9).

It has been shown that the driver and the infantry section (APC) have a considerable manual workload during the battlefield day; on the other hand the commander and the gunner (e.g.) require mainly mental and sensory faculties. The loader (MBT and CVR(T)) does manual work only in contact, and for replenishment. It is likely that the main NBC constraint on both sensory perception and manual work capability is the wearing of the individual respirator while the NBC suit is a second important constraint

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when manual work is required. The constraints on the crew performance outlined above might tend to reduce combat efficiency; some effects may be negligible, on the other hand some may be gross. The relationships between NBC protection and combat efficiency must be formulated in such a way that the magnitude of the effects and their relative importance can be evaluated, and interaction of effects noted.

Nature of Combat Efficiency

11. Possible changes in combat efficiency due to the adoption of NBC protection may be considered in two parts (see 9 c.):-

- a. skill inhibition, i.e. the degradation in performance of fresh, non-fatigued personnel due to the physical constraints imposed by the protection,
- b. accelerated fatigue, i.e. the shortening of crew endurance time due to the faster onset of fatigue because of the physiological and psychological constraints imposed by the protection.

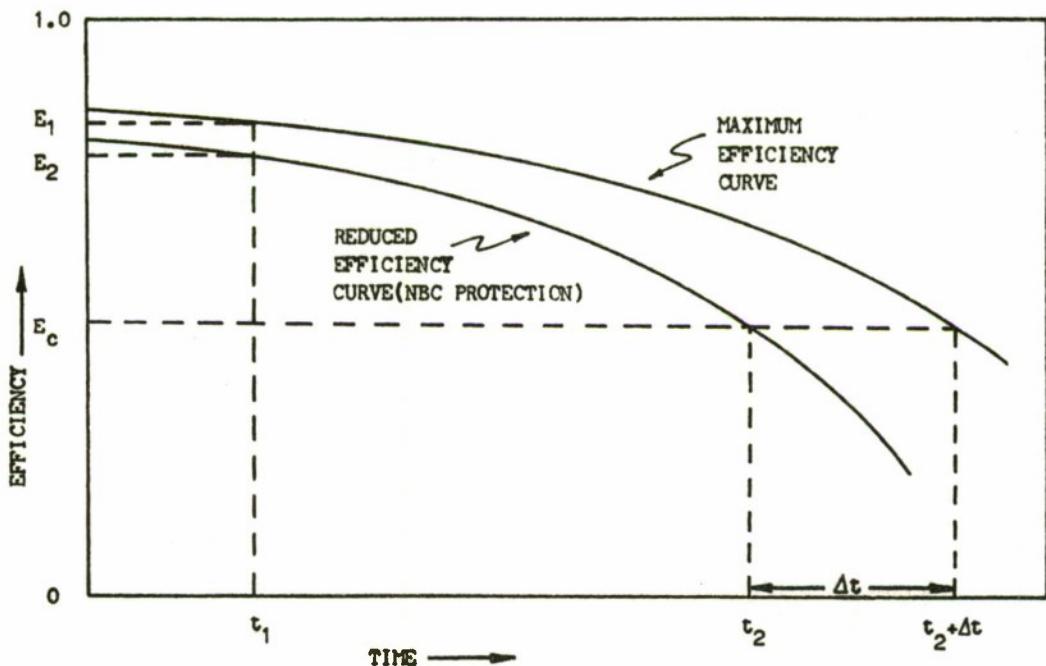
It is clear that in a contact situation 11 a. will have an immediate effect and that 11 b. will result in an earlier onset of battle fatigue than would otherwise have occurred. It becomes obvious that combat efficiency depends on a number of variables e.g. temperature, visibility and crew comfort. Thus, if it were to be plotted against time, a family of curves could be obtained, each curve being characterised by a specified set of variables. Such families of curves could be drawn to represent the maximum efficiency, i.e. that obtaining without the presence of constraints such as NBC protection, and also for the reduced efficiency obtaining in the presence of NBC protection. These curves may not be continuously decreasing functions of time, indeed they may well fluctuate with time, e.g. after periods of sleep or eating. However, the situation is most conveniently represented as in figure 1, where for a given set of circumstances, efficiency decreases with time and the curve for NBC protection is shown lower than that of the maximum efficiency curve.

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These curves are postulated in order to illustrate where optimisation is required. Both a. and b. above are illustrated in figure 1 in that at short times the "fresh troops" show a decrease in efficiency, i.e. skill inhibition, and at longer times the efficiency has dropped to a given level ( $E_c$ ) after a shorter time for the protected conditions. From the diagram, the efficiencies  $E_1$  and  $E_2$  at time  $t_1$  illustrate the degradation as described in a., and the time interval  $\Delta t$  illustrates that in b. If troops have to be withdrawn at an efficiency level  $E_c$ , then the degradation is in terms of the efficiencies at time  $t_2$ , and the effective combat time lost is  $\Delta t$ .

FIGURE 1. EFFECT OF PROTECTION ON COMBAT EFFICIENCY: COMBAT EFFICIENCY VS TIME



12. In figure 1, efficiencies in arbitrary units are shown as a function of time, but in order to describe combat efficiency fully it must be capable of being expressed in some unit or units, and must reflect the purpose for which the AFV was designed. Although special occasion may call for a peak of efficiency, which must of necessity be of limited duration, in general it does not seem profitable to provide this peak if by so doing the time in action, or available for action, is seriously curtailed as a

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result. Similarly it is pointless to provide so much protection that survival, or time in action, is extended if in so doing the efficiency in terms of offensive capability becomes unacceptably low. Thus, combat efficiency must contain some statement of time or of frequency in some form, e.g. the number of contacts it is expected to survive before it ceases to be an effective unit, and may be described in terms of a time-efficiency potential.

13. In figure 1, if the curve for maximum efficiency represents the ideal, then the optimum for the reduced efficiency curve should lie as close as possible to this ideal. However, it may be expedient to optimise protection such that, either the curves are close at short times and not necessarily so at longer times, or that some reduction in efficiency is acceptable at short times if the time in action at above a certain efficiency could be maintained, i.e. by a reduction in  $\Delta t$ . This is a problem that must be solved for each type of AFV (e.g. MBT, APC), and indeed for each individual AFV (e.g. Chieftain, FV432): in order to obtain a solution, the purpose of the AFV and the tactical situations in which it might be found must be investigated. In this way the factors contributing to combat efficiency that are affected by NBC protection, and their relation to the tasks in the variety of tactical situations, can be established and analysed.

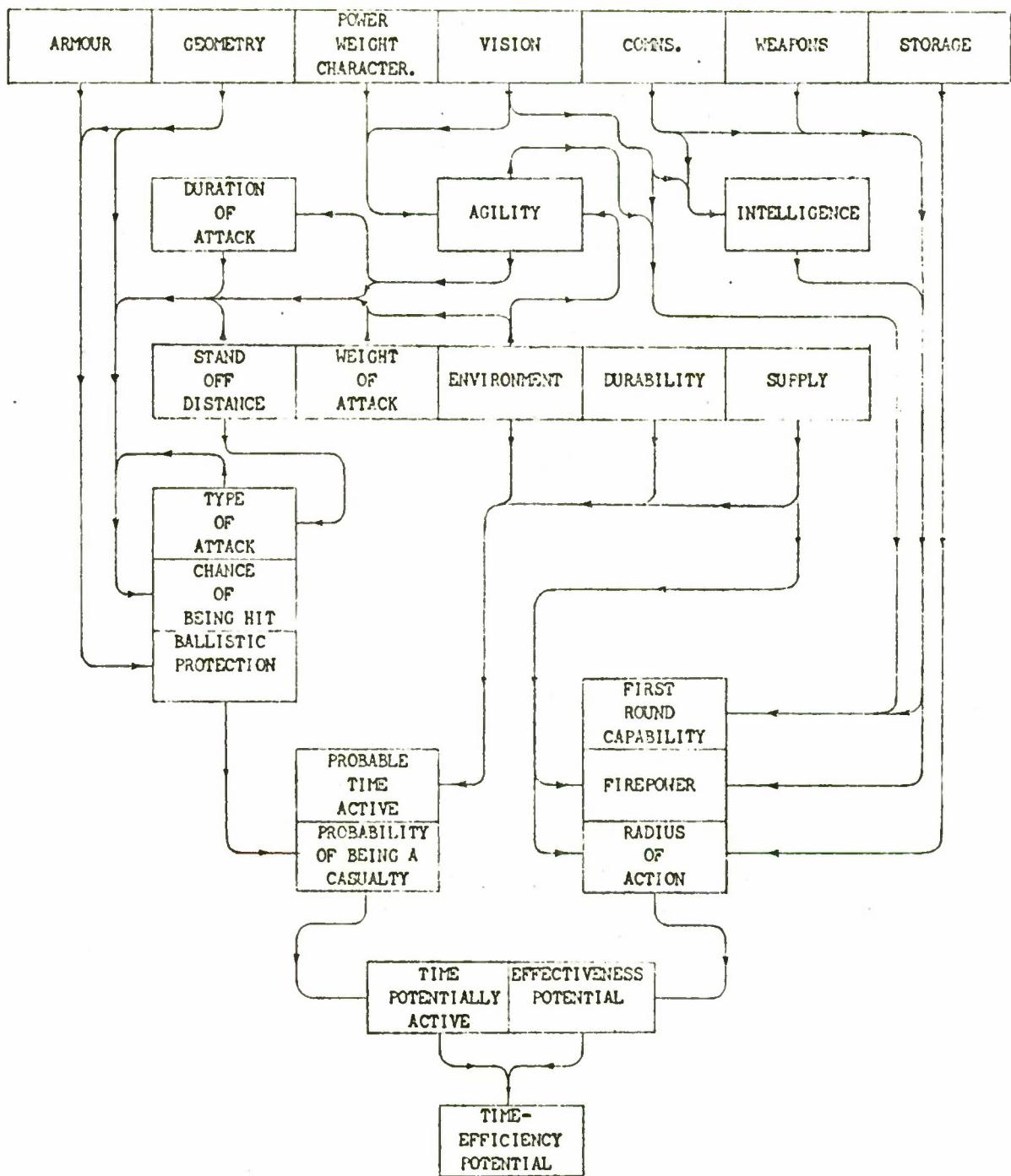
Relation of Crew Skills to Operational Tasks

14. It can be seen that the tasks that have to be accomplished are dealt with by the crew through the operation of the vehicular equipment, and the efficacy of the combination has to be established. The way in which the attributes\* of an AFV interact with

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\* Attribute. Quality ascribed to an AFV; object recognised as appropriate to the purpose of an AFV; characteristic quality.

FIGURE 2. FUNDAMENTAL CAUSE AND EFFECTS DIAGRAM.



FLOW LINES LEAVE THE BOXES FROM THE TOP OR THE BOTTOM, THEY ENTER THE BOXES AT THE SIDE(EXCEPT LAST).

FLOW LINES LEAVING BOTTOM OF VERTICAL STACKS OF VARIABLES REFER TO ALL THE VARIABLES IN THAT STACK.

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its environment and the crew to make it into an effective fighting unit are shown in figure 2. This is a cause and effect diagram which illustrates how attributes of the AFV needed to carry out its tasks, and the environment in which the tasks will be carried out, in the form of input variables, interact through intermediate variables to contribute to a term representing combat efficiency. The variables are defined in Annex C.

15. AFV's have basic characteristics which distinguish them from other vehicles. These are, in general,

- a. mobility
- b. weapons (see footnote)
- c. armour
- d. crew.

These characteristics have been expanded in the form of input variables (first row of boxes in figure 2) which might be required for their operation. The variables which require crew interaction do not have this stated explicitly in the diagrams; it is understood. The diagram shown in figure 2 is a general one; for a given set of tasks the variables may be manipulated to yield the requirements for a given AFV or type of AFV to deal with these tasks.

16. Environmental factors which might affect the performance of the AFV in carrying out its tasks are, again, presented in the form of variables (third row of boxes in figure 2). These are independent or pseudo-independent in that factors external to the vehicle can control them.

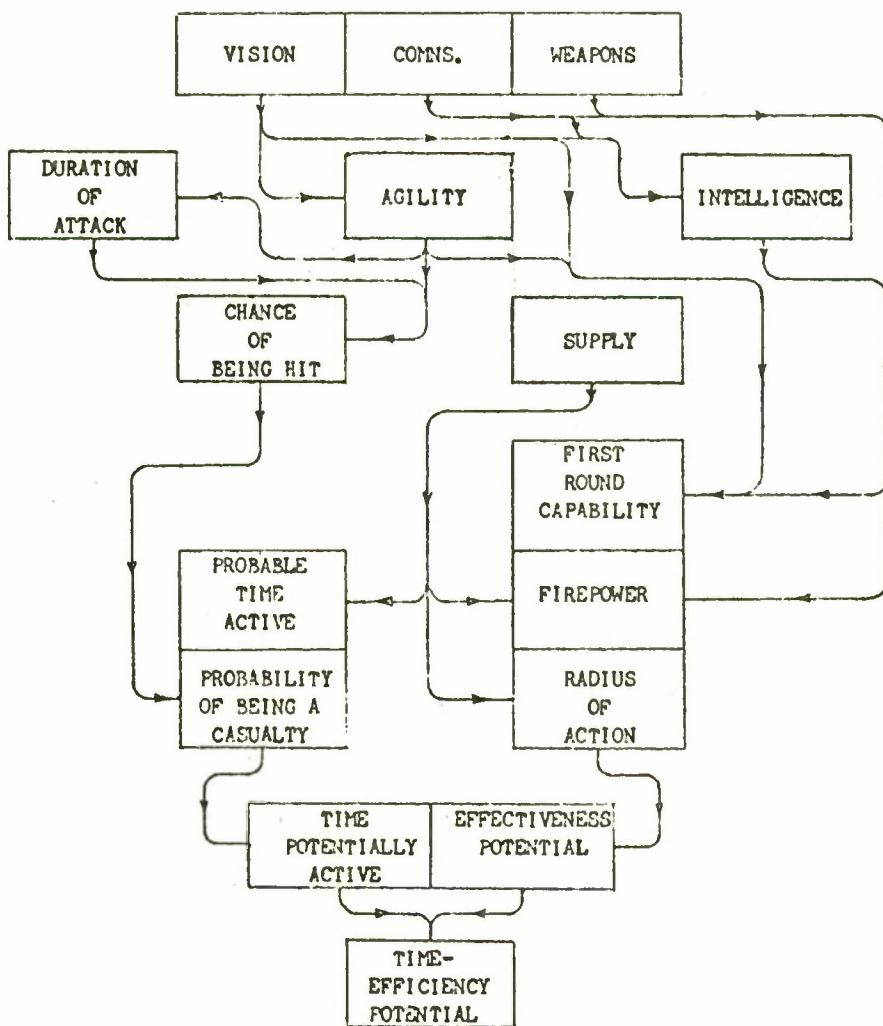
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Footnote: Weapons here refer to the vehicle-mounted system rather than to the whole system: for main battle tank it includes the main gun, machine guns, and other equipments capable of firing projectiles. Also, for the APC, the infantry section being carried may be included under this heading.

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FIGURE 3. REDUCED CAUSE AND EFFECTS DIAGRAM SHOWING THOSE VARIABLES THAT WOULD BE AFFECTED BY DEFENSIVE MEASURES AGAINST NBC AGENTS.



FLOW LINES LEAVE THE BOXES FROM THE TOP OR THE BOTTOM, THEY ENTER THE BOXES AT THE SIDE(EXCEPT LAST)

FLOW LINES LEAVING BOTTOM OF VERTICAL STACKS OF VARIABLES REFER TO ALL THE VARIABLES IN THAT STACK.

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17. The variables remaining in figure 2 that contribute to time-efficiency potential are called intermediate variables. These all have some dependence on the input variables either directly, or indirectly through other intermediate variables.

Effect of Crew Protection on Combat Efficiency - Reduced Diagram

18. In general, the left half of figure 2 describes defensive ability, while the right half describes offensive ability. The effects of protection against NBC agents will be effective through those variables where the crew is involved in the execution of a skill associated with the variables. Thus the part of the diagram affected by the protection can be isolated by examination of the input variables, and including in a reduced diagram only those input variables that would involve the crew, and their associated dependent intermediate variables. Figure 3 shows such a reduced diagram. Note that, apart from containing those variables requiring an intimate crew interaction, the right half of figure 2, i.e. that concerned with offensive ability, has been included in its entirety.

Importance of Variables Contributing to Combat Efficiency

19. In the cause and effect diagrams flow lines link the variables and show how the input variables are effective and the extent of interaction; however, these flow lines show neither the magnitude nor the relative importance of the variables. The reduced cause and effect diagram (figure 3) includes only those variables likely to be affected by NBC protection, and to specify the protective system most suited to the needs of an AFV the combat efficiency must be studied through these variables. However, an AFV, or type of AFV, will have been designed and built to fulfil a number of requirements drawn up from a consideration of tactical situations or operational tasks; thus for different AFV's the variables will take different forms and are of different relative importance.

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20. During the battlefield day (ref. 8) an AFV will be required to be capable of performing a number of operational tasks in a variety of tactical situations, and each operational task can be assigned some value of importance. For each task the variables have some order of importance; by giving them suitable weightings in each case, and by integrating over the operational tasks for the battlefield day, the appropriate weightings being taken into account, it is possible to obtain an assessment of the overall relative importance of the variables. This process may be simplified by determining the principal roles of each type of AFV, and by grouping the tasks in these roles into several types of AFV activity (ref. 8), so that in each group the variables have similar relative importance. The groups, and the variables in each group, can be weighted in order of importance and this enables the relative importance of the variables for that AFV to be established.

21. Having such a knowledge of the importance of the variables enables the appropriate aspects of the operation of an AFV to be isolated and studied so that suitable protection can be suggested. It must be noted that even if combat efficiency is degraded, the importance of the variables is still the same.

PREPARATION OF QUESTIONNAIRES

22. The CD Guide gives guidance on the tasks to be accomplished by U.K. forces on the Central Front and Flanks in Europe. The importance of the variables that would be affected by protection against NBC attack in carrying out these tasks have been obtained for several types of AFV by canvassing user opinion. Questionnaires were prepared in which the tasks to be performed by a type of AFV were represented by several types of AFV activity. For each of several types of AFV, representative users were asked to give a value of importance to each of the types of activity, so that the sum of such values was 10.

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Selection of Variables

23. It was noted earlier that in the reduced diagram (figure 3) the variables are concerned mainly with offensive ability. These are the variables which are NBC sensitive, and it is these selected variables, and not all of those included in the fundamental cause and effect diagram (figure 2), which are included in the questionnaires.

24. The variables whose importance is required, and which have been included for assessment on the questionnaires are, therefore, those mainly concerned with the AFV's offensive ability, viz:-

vision, communications, weapons, supply, agility.

The first four of these variables are independent input variables; however, it was considered necessary to include the pseudo-independent variable, agility, in the questionnaires, realising that this latter variable has a partial dependence on the driver's vision.

25. Users were asked to weight the listed variables in importance for each of the activity types so that for each activity type the sum of the importances attached to each of the variables equals 10. The importance of a variable to the performance in a given activity type, multiplied by the importance of that activity type, is taken as representing that contribution of the variable to the overall tasks of the AFV. Thus by summing such products for each variable over all the activity types, the relative importance of each variable to the AFV in performing its necessary tasks is obtained.

Types of AFV and Their Activities

26. The following groupings into type of activity have been made in consultation with the RAC Centre and the School of Infantry (ref. 8), for the types of AFV as given in para 8 b.

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Main Battle Tank

27. Activities have been grouped under three main headings, viz:-

Destruction of Enemy Armour. This includes reconnaissance of positions, routes and hides, movement to battle positions, observation, target acquisition and engagement, contact reports, fire and manoeuvre and battle replenishment.

Close Combat in Conjunction with Infantry. This may include all the points listed above and also fire support for infantry on foot or in APCs, assault of enemy-defended positions, close protection of infantry on the move or in defended positions.

Waiting for Battle to Begin. This includes receiving orders, moving to hides or assembly areas, rest, radio watch, sentry duties, servicing and routine replenishment.

Mechanized Infantry Combat Vehicle

28. Apart from assessments of RV and APC's, user opinion was also canvassed in a similar way for MICV although this is conceptual. Activities have been grouped under three headings, viz:-

Carriage of Infantry Section. Includes carriage to and from dismounted positions, and may also include reconnaissance of positions, routes and hides, movement to battle positions, observation, target acquisition, contact reports, fire and manoeuvre and battle replenishment.

Engagement of Enemy Light AFV's. May include all the points listed in para 28. above, and also fire support for infantry on foot or in other APCs, assault of enemy-defended positions, protection of infantry on the move or in defended positions.

Waiting for Battle to Begin. Includes receiving orders, moving to hides or assembly areas, rest, radio watch, sentry duties, servicing and routine replenishment.

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Reconnaissance Vehicle.

29. For this type of MICV the activities have been grouped under four headings, viz:-

Tasks Involving Stealthy Observation and Reporting and Possibly Imposing a Measure of Delay on the Enemy (Covering Force and Flank Protection). This includes reconnaissance of positions, routes, OPs and possibly hides, observation and reporting, target acquisition and engagement, especially of enemy reconnaissance elements, ambushes, fire and manoeuvre and possibly replenishment.

Mobile Tasks Such as Advance to Contact, Pursuit, Anti-Airborne or Heli-borne Operations (Contact very likely). Includes some or all of the points listed above under "stealthy observation", and probing forward using various movement drills and looping round enemy positions.

Mobile Tasks Such as Escorts, or Nuclear and Chemical Reconnaissance (Contact less Likely).

Waiting for Operations to Begin. This includes receiving orders, moving to hides, assembly areas or OPs, rest, radio watch, sentry duties, servicing and routine replenishment.

Armoured Personnel Carrier.

30. a. In Straight APC Role. Activities have been grouped under two headings, viz:-

Carriage of Infantry Section. Includes carriage to and from dismounted positions, and also may include reconnaissance of positions, routes and hides, movement to battle positions, observations, target acquisition, contact reports, fire and manoeuvre and battle replenishment.

Waiting for Battle to begin. Includes receiving orders, moving to hides or assembly areas, rest, radio watch, sentry duties, servicing and routine replenishment.

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b. With Turret Mounted Weapon. Activities have been grouped under three headings, viz:-

Carriage of Infantry Section. As in para 30 a. above.

Engagement of Enemy Light AFV's. May include all the points listed in "Carriage of Infantry Section" and also fire support for infantry on foot or in other APC's, assault of enemy defended positions, close protection of infantry on the move or in defended positions.

Waiting for Battle to Begin. As in para 30 a. above.

31. Completed questionnaires have been analysed and results of rank correlation tests, analysis of variance, statistics and assigned weightings of importance are given in Annex D.

SUMMARY OF RESULTS

32. The results given in Annex D (vii) are summarized and presented below in Table 2. The weightings of importance of the various activities and variables (functions) towards the combat efficiency of the AFV's are shown along with their standard errors. It can be seen that in several instances in the Table, although an ordering of importance may be made, there is no significant difference between weightings, e.g. between weapons, communications and section carried for APC(2).

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Table 2. Weightings of Importance of AFV Activities and of NBC-Sensitive Variables for Various AFV's

Activity	AFV				APC (1)	APC (2)
	MBT	MICV	RV	APC (1)		
Destruction of Enemy Armour	0.48 ± 0.01	-	-	-	-	-
Engagement of Enemy Light AFV's	-	0.27 ± 0.04	-	-	-	0.36 ± 0.02
Close Combat in Conjunction with Infantry	0.30 ± 0.01	-	-	-	-	-
Stealthy Observation and Reporting, Imposing Delay	-	-	-	0.42 ± 0.02	-	-
Mobile Duties such as Advance to Contact, Pursuit	-	-	0.27 ± 0.02	-	-	-
Mobile Duties such as Escorts, NBC Reconnaissance	-	-	0.16 ± 0.02	-	-	-
Carriage of Infantry Section	-	0.48 ± 0.03	-	0.65 ± 0.02	0.43 ± 0.02	-
Waiting for Battle to Begin	0.22 ± 0.01	0.26 ± 0.02	0.16 ± 0.02	0.35 ± 0.02	0.21 ± 0.02	-
Variable						
Weapons	0.29 ± 0.01	0.16 ± 0.02	0.18 ± 0.01	-	0.21 ± 0.02	-
Communications	0.23 ± 0.01	0.24 ± 0.01	0.32 ± 0.01	0.25 ± 0.01	0.23 ± 0.02	-
Vision	0.19 ± 0.01	0.13 ± 0.01	0.18 ± 0.01	0.14 ± 0.02	0.15 ± 0.01	-
Agility	0.14 ± 0.01	0.22 ± 0.02	0.20 ± 0.01	0.15 ± 0.02	0.15 ± 0.01	-
Supply	0.15 ± 0.01	0.13 ± 0.02	0.12 ± 0.01	0.12 ± 0.01	0.07 ± 0.01	-
Section Carried	-	0.12 ± 0.02	-	0.35 ± 0.01	0.20 ± 0.02	-

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DISCUSSION

Resume of Theoretical Development

33. It has been shown that combat efficiency may be reduced by the adoption of defensive measures against the NBC threat. This combat degradation can take two forms, viz. skill inhibition and accelerated fatigue. The alternative defensive postures available to AFV crews are individual protection and collective protection; these are likely to affect combat efficiency in different ways and each posture may offer advantages over the other in appropriate circumstances. Analysis of the activity of an AFV crew in battle and of the battlefield day shows that a relatively short time may be spent in contact with the enemy, during which time the crew must work at maximum efficiency, and that a relatively long time may be spent while waiting for battle to begin, during which time maximum rest and relief are needed. Thus the problem of maintaining combat efficiency while protected against NBC attack must be studied bearing in mind the alternative postures available, and the conflicting interests of the crew in the various phases of battle, in order to obtain an optimum solution for each type of AFV.

34. It was decided to measure the degradation of combat efficiency caused by NBC defence by means of field trials rather than by simulation techniques, and the problem then became one of designing suitable field trials and realistic measures of combat efficiency.

35. The combat efficiency of an AFV crew/vehicular system is a difficult property to examine due to the large number of factors which contribute to it. An attempt has been made to represent these factors as vehicular and environmental variables which have been defined in a way which isolates them into unique functions; these are independent variables which interact in a real situation in a very complex manner. The interactions have been described using a cause and effect diagram which shows how the input variables (the vehicular and environmental variables) act through various intermediate variables to contribute to combat efficiency, the latter being defined as

a time-efficiency potential. Thus a descriptive model of the combat efficiency for AFV's has been obtained. The extent of interaction of the variables can be seen, but the degree and magnitude of interaction cannot be gauged from such a diagram. However, its use is that the effects of imposed constraints on the input variables and hence on combat efficiency can be traced. An analysis of crew activities enables the input variables that would be affected by NBC protection to be identified. A reduced diagram is thus obtained by isolating those input variables and the intermediate variables that are dependent on them; this reduced diagram includes only those variables which would be affected by protection against NBC attack.

Results Obtained from Questionnaires

36. The NBC sensitive variables that have been isolated in this way are:-

weapons, communications, vision, agility, and supply. Where necessary, the section carried has been included as part of the "weapons". To examine combat efficiency through these variables their importance must be known, and this was found by canvassing User opinion by means of carefully constructed questionnaires. The tasks to be performed by a type of AFV were represented in the questionnaires by several types of activity. From an analysis of these questionnaires the results shown in Table 2, para 32, were obtained.

37. The results must be considered with a little care; Users were asked to give weightings of importance on a scale effectively from 0 to 1.0. Most replies were quoted to 0.1 and some to 0.05: this is reflected in the sample standard deviations (see Annex D (vii), page 56). Although the scale of importance for the larger weightings may be linear, reflecting the way the Users allocated them, that for the smaller weightings may not be so. However, in Table 2 the values quoted are considered sufficiently large for the assumption of linearity to be assumed, and to be a realistic quantification of User opinion. The weightings given are the means of the samples canvassed, and the standard error of the means

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are also shown; thus, although an ordering of importance may be assigned from the above Table (c.f. para 32) some of the precedence may be seen to be not significant due to the error of the means. Also, as the weightings for a given AFV are correlated, care must be taken in comparing values for a variable or activity between different AFV's. For example, for a given variable, unless the ratios of weightings for the other variables are similar for different AFV's, no true comparison can be made.

38. In the design of field trials based on the results in this report, the variables to be examined are determined by the values in Table 2. The context or scenario in which they will be measured will be determined by the weightings of importance given to the AFV activities. Thus, for example, in designing a trial concerning the protection of the crew of an MBT it can be seen that the most important activity in this context is DESTRUCTION OF ENEMY ARMOUR, its importance being about 50%; however, CLOSE COMBAT IN CONJUNCTION WITH INFANTRY and WAITING FOR BATTLE TO BEGIN are not of negligible importance. The scenario must therefore be designed around an armour - heavy battle-group. Examination of the variables for MBT shows that AGILITY and SUPPLY are not significantly different in importance, but that the other variables are. WEAPONS is most important, followed by COMMUNICATIONS and VISION: it is noticeable that the distribution of weightings is not very wide. Thus a suggestion for the form of a trial is that, in an armour-heavy engagement with enemy, the operation of the weaponry is examined frequently and in some detail by presentation of suitable targets: timings and accuracy would be noted. COMMUNICATIONS would be monitored, possibly by recording on tape all messages within the tank, and between the tank and its command vehicle. VISION can be examined by taking note of the proportion of targets acquired and identified correctly, and AGILITY and SUPPLY monitored in some simpler and less sophisticated manner than for the other variables. A suitable mix of targets, and simulation of battle

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progress, would thus enable the variables to be examined as the priority of importance indicates. It is important to note however, that although the above activities and variables are being monitored, those variables which would not be affected by NBC protection are still extant, and care must be taken that these exist in the trial as they would in a real situation.

CONCLUSION

39. The results that have been obtained and presented in this report can be used to help in the design of field trials to study combat efficiency and the effects of NBC protection. The factors contributing to the combat efficiency of the crew members of AFV's, and identification of those factors sensitive to NBC protection has been achieved. Also, the principal roles of the AFV's considered have been studied and the importance of the various NBC sensitive variables in each role found.

40. Preliminary trials have been performed using a Chieftain tank, and a report on these will be forthcoming. Trials with the other AFV's are planned and will be performed as and when time allows.

ACKNOWLEDGEMENT

I would like to thank the staff of the RAC Centre and of the School of Infantry for their help and advice in the construction of the questionnaires, and for arranging for their completion by representative Users.

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REFERENCES

1. Annex A. Summary of the NBC Threat (1970-1990).  
DNBCS 101924G CDE Ptn/TG2001/5529/69. The Effects of The Threat or Use of Chemical Agents on Military Operations in the Period 1981-1990. December 1969.
2. Annex B. Possible Protective Systems in AFV's.
3. e.g. Army Combat Development Guide 1981-1990.
4. e.g. APRE Report No.12/66. A Review of Human Factor Aspects of Fighting Vehicles. December 1966.
5. AORE Res Memo No.5/64. A Study of Unit Activity and Protection. June 1964.
6. Symposium on Human Engineering Aspects of Main Battle Tank Design. Royal Military College of Science, Shrivenham. April 1969.
7. Rank Correlation Methods. Morris G. Kendall. Charles Griffin & Co. Ltd. 1948.
8. e.g. refs 5 and 6, and consultation with RAC Centre, Bovington, and School of Infantry, Warminster.
9. C.W. Proofing and Compatibility Trials of the Chieftain Mk. 3. MBT. Part I. C.W. Proofing Trials.  
Part II. Compatibility Trials.  
C.D.E. F.T.R.18.

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ANNEX A

Summary of the NBC Threat (1970-1990)

1. The following agents or hazards may be encountered on the battlefield:-

a. Chemical Agents

1. Lethal

Non-persistent, liquid	GB
Semi-persistent, liquid	GD
Persistent, liquid	V, H
Persistent, solid	Toxins

2. Incapacitating

Mental/Physical, short action	BZ, UC
long action	BZ, Toxins

3. Riot Control

Short Action	CS
--------------	----

b. Biological Agents

c. Nuclear Radiation Hazards

At Burst	Blast Heat Radiation, Neutron Flux X Rays γ Rays
Fallout	Radioactive particles, α, β, γ and n-emitters

2. The agents or hazards may be encountered in the following physical forms:-

a. Vapours. Chemical agents only. Counteracted by charcoal filtration unit in the S6 Respirator or NBC filtration pack.

b. Particles.

1. Aerosols. <10 µm diameter. Chemical and biological agents and a small fraction of nuclear fallout. Counteracted by particulate filters in the S6 Respirator or in the NBC filtration pack.

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2. Fine Spray. 10  $\mu\text{m}$ -500  $\mu\text{m}$  diameter. Chemical agents and a large fraction of nuclear fallout. Counteracted by protective clothing, overhead cover, by the cyclone filters in the NBC pack, and by decontamination procedures.
3. Coarse Spray. 0.5 mm-3 mm diameter. Mainly chemical agents (rain). Counteracted by protective clothing, overhead cover in vehicles and buildings etc., and by decontamination procedures.

c. Liquids. Mainly chemical hazard. Counteracted by protective clothing, decontamination procedures.

d. Nuclear Radiation. General ambient radiation reduced by shielding effect of armour (and special shielding if fitted). Dust excluded from AFV interior by cyclone and particulate filters.

3. The agents or hazards may be delivered by the following methods:-

- a. Direct hit by projectile

HEAT + agent injection (follow through)	C (Chemical)
AP + interior burst	C
Break up shot	C
- b. Close burst by projectile

Target within initial cloud radius	C
------------------------------------	---
- c. Distant release of agent

Vapour/aerosol cloud drifting downwind	NBC (Nuclear, Biological, Chemical)
--	-------------------------------------
- d. Aerial delivery of particles

VT fuse artillery (TOT)	BC
Aircraft release at $\sim$ 50 m	BC
Missile release at $\leq$ 2000 m	BC

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e. Radiation Hazard

Initial burst	N
Fallout	N

f. Ground contamination

Pickup	NBC
Vapour/aerosol	NBC
Radiation	N

4. Some tactical uses of Chemical Agents are:-

- a. Large area attacks, especially when nuclear weapons are undesirable and enemy positions are ill-defined.
- b. To exploit the confusion after a nuclear attack.
- c. To help channel enemy into an area suitable for nuclear attack.
- d. In conjunction with other conventional weapons.
- e. Attack near a civil population.
- f. To penetrate hard targets.
- g. Harassment and interdiction during attack or defence.
- h. To form defensive barriers, e.g. by supplementing conventional minefields.
- i. To provide close support.
- j. To neutralize landing zones, airfields etc.
- k. To attack in difficult or sheltered terrain, e.g. wooded areas, broken country.
- l. To contaminate stores, equipment and supply routes.
- m. To allow rapid follow up by own troops, when creation of obstacles is undesirable.
- n. To hamper reconnaissance, surveillance and target acquisition by restricting movement or denying ground.
- o. To facilitate capture of enemy.
- p. As a non-destructive weapon.

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30.

Possible Protective Systems in AFV's

1. Individual Protection

With the AFV closed down the crew would wear the NBC suit, and the S6 respirator coupled to an AFV blower system. The vehicle ventilation would include

air intake→cyclone filter→fan→vehicle air (~118 l/s, 250 cfm)  
heater/cooler→fan→S6 respirator (~47.2 l/s, 100 cfm, per man)

The cyclone filter prevents ingress of 99% of particulate matter of  $>10\mu\text{m}$  diameter, i.e. nuclear fallout plus coarse BC particles. In a BC environment respirators would be worn continuously. There are limited power requirements for this type of system. The interior of the vehicle may become contaminated by liquids or solids brought in by the crew (c.f. Annex A, para 3 f.). The only expendable items would be the S6 canisters and the cost per vehicle for this type of system would be in the order of £700.

2. Full Vehicular Collective Protection

The vehicle ventilation system would now include

air intake→cyclone filter→particulate filter (coarse and fine)→fan→charcoal vapour filters→heater/cooler→vehicle interior.

There would also be a by-pass from the cyclone filter to the heater/cooler. This system would operate at about 118 l/s (250 cfm) to give an overpressure inside the vehicle of  $750 \text{ N/m}^2$  (3 in w.g.):

- a. The cyclone filter operates as above.
- b. The particulate filters will need replacement periodically and this will depend on the environment.
- c. The charcoal filters will need replacement after use in an NBC environment. Against V, G and H agents they should last at least 8 days; against AC or CK they should protect during 1 or 2 attacks.

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- d. The heater/cooler system will require considerable power. Individual heater/cooler systems may be an alternative to space control.
- e. In general full protection would be given against all NBC hazards and respirators need not be worn.
- f. The protection may be broken (Annex A, para 3 a, b and f). Until the vehicle interior becomes contaminated there will be no need for alternative protective systems.
- g. Decontamination of the interior of the vehicle is likely to be very difficult.
- h. The cost per vehicle for this type of system would be in the order of £1500.

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ANNEX C

Definitions of Variables Used in Cause and Effect Structure

1. Input Variables

a. AFV Variables

Armour. The AFV's defensive covering, affording ballistic protection.

Geometry. The size and shape of the AFV; the slope of the armour and the silhouette are the more important factors.

Power-Weight Characteristics. The factors which make up the vehicular qualities of the AFV such as acceleration, track loading, net torque, net b.h.p., and speed.

Vision. What can be seen or the ability to see from the AFV, either directly or by use of optical instruments or aids. It incorporates field of view, acuity, and ability to spot potential targets.

Communications. The system whereby the AFV crew transmit or receive information amongst themselves or outside agencies. It includes electronic and electric equipment and the ability to use it. Apart from hardware it also includes more transient facilities such as voice procedure.

Weapons. Generally referred to the means of delivery of projectiles or explosives, although it could be extended to cover the transport and delivery of an infantry section in an infantry carrier. It includes the hardware, laying, loading and firing (delivery), and the instrumentation necessary to do so, except where this is defined under another variable.

Storage. A volume or a capacity limit, e.g. fuel capacity. It does not include stocks ready to be drawn upon, e.g. in the sense that ammunition stowage is assumed adequate for immediate needs and is part of weapons. In the diagram its dependent variables indicate its meaning.

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b. External or Environmental Variables

Note that when attack is referred to this means one aimed at the AFV.

Stand-off Distance. The distance between the AFV and the enemy delivery system.

Weight of Attack. (Satis).

Environment. Local terrain, topology, and to some extent the local meteorological conditions.

Durability. A number of factors have been included under this heading as an expedient. For example it gives a probable time between servicing or maintenance, and in some way measures robustness. It depends on other variables to some extent but is conveniently defined uniquely; it influences and puts an upper limit on probable time active.

Supply. Although when resupplying this is not an independent variable, the circumstances for its execution and inception are independent in the present context.

2. Intermediate Variables

Duration of Attack. The time during which the AFV could be damaged by the attack.

Agility. Includes such factors as speed, acceleration, stopping power, stability, turning circle, adaptability to terrain and nimbleness.

Intelligence. Everything concerned with the receipt and transmission of information, and the recording and use of it. Assuming that the AFV is in a given situation, then it is independent of the attack modes.

Type of Attack. Attack other than BC.

Chance of Being Hit. (Satis).

Ballistic Protection. Protection afforded by the armour against projectiles.

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Probable Time Active. An expression of the vehicle's capability to remain a fighting unit. Analogous to fatigue in the crew.

Probability of Being a Casualty. (Satis).

First Round Capability. Capability to locate a target and to range on and to engage it.

Firepower. The ability to destroy any target presented as quickly as possible.

Radius of Action. That within which the AFV may be an effective fighting unit, allowing that some resupply may be necessary.

Time Potentially Active. The time that the AFV will be able to be effective.

Effectiveness Potential. Level of efficiency the AFV could achieve if necessary.

Time-Efficiency Potential. This is defined by the cause and effect diagram (figure 2).

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ANNEX D

Questionnaires

i. Form of Questionnaires

Samples of the five questionnaires are shown on pages 39 to 43. They include those for

Main Battle Tank (Tanks)

Mechanised Infantry Combat Vehicle (MICV)

Reconnaissance Vehicle

Armoured Personnel Carrier, Armed (FV 432 with  
turret mounted weapon)

Armoured Personnel Carrier (FV 432 in straight APC  
role).

Results from the questionnaires are given in pages 45 to 51. The replies are arranged according to rank of user and the weightings of importance are given for activity type and for the variables (function). The weightings have also been ranked in order of importance, i.e. the highest weighting has been given a ranking of 1. The weightings of importance of the variables were obtained by multiplying the weighting of a variable under a given activity by the weighting of that activity. This was repeated for each activity, and the sum of such products for each variable gives the weighting shown in the table. Rank correlation tests were performed to test the degree of agreement in the questionnaires before an analysis of variance was performed on the weightings. Results of these analyses are given on pages 55 and 56. In the tables the weightings given to the variables (functions) have been reduced by a factor of 100, so that the sum for a given respondent is 1.

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RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF A TROOP IN A TANK DURING OPERATIONS

1. Rank .....  
2. Appointment ..... (tank troop leader,  
squadron leader, etc) 3. Experience .....  
4. Place ..... (NOT BFPO number please). (two years commanding a  
troop etc.)

Function Series	Activity			Waiting for Battle to Begin. Includes receiving orders, moving to hides or assembly areas, rest, radio watch, sentry duties, servicing and routine replenish- ment.				
	Destruction of Enemy Armour.	Close Combat in Conjunction with Infantry. May include all the points listed in colm (c) and also fire support for infantry on foot or in APCs, assault of enemy defended positions, close protection of infantry on the move or in defended positions.	Waiting given to Function	(a)	(b)	(c)	(d)	(e)
1 Weapons 2 Comms 3 Agility 4 Vision 5 Supply 6 Weighting of Activity								

Notes

1. Fill in the headings above the table.
2. Consider columns (c) (d) and (e) separately. Complete Serials 1-5 by giving a figure for each function to show the relative importance you attach to it in carrying out the activity. The total of the weightings must be 10. See the completed example.
3. Consider the three activities in columns (c) (d) and (e) together. Complete Serial 6 by giving a figure in each column to show the relative importance you attach to each activity. The total of your figures in the three columns must be 10. See the example.
4. Leave column (f) blank.

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RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF AN MICOV DURING OPERATIONS

1. Rank .....
2. Appointment .....

3. Experience .....

4. Place .....

		Activity					
		Carriage of Infantry Section.		Engagement of Enemy Light AFV's.		Waiting for Battle to Begin.	
		Includes carriage to and from dismounted positions, and also may include reconnaissance of positions, routes and hides, movement to battle positions, observation, target acquisition contact reports, fire and manoeuvre and battle replenishment		May include all the points listed in coln(c) & also fire support for infantry on foot or in other APC's, assault of enemy defended positions, close protection of infantry on the move or in defensed positions.		Includes receiving orders, moving to hides or assembly areas, rest, radio watch, sentry duties, servicing & routine replenishment.	
		Function		Weighting Given to Function		(e)	
		(a)		(b)		(c)	
		1 'Dismntd' Section.		(d)		(e)	
		2 Vhcle Mtd Wpns Cmmctns.		(f)		(g)	
		3 4 Agility. 5 Vision.					
		6 Supply					
		7 Weighting of Activity					
40.							

Notes. 1. Fill in the headings above the table.

2. Consider columns (c), (d) and (e) separately, complete Serials 1-6 by giving a figure for each function to show the relative importance you attach to it in carrying out the activity. Regard Serials 1 and 2 as comprising the 'Weapon' of the MICOV. The total of the weightings must be 10. See the completed example.

3. Consider the three activities in columns (c), (d) and (e) together. Complete Serial 7 by giving a figure in each column to show the relative importance you attach to each activity. The total of your figures in the three columns must be 10. See the example.

4. Leave column (f) blank.

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## RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF A RECONNAISSANCE VEHICLE IN A TROOP DURING OPERATIONS

1. Rank .....  
 2. Appointment ..... (troop leader,  
    squadron leader, etc)

3. Experience ..... (two years commanding a troop, etc)  
 4. Place ..... (NOT BFPO number please)

		Activity						Waiting for Operations to Begin.	
		Mobile Tasks such as Advance to Contact, Pursuit, Anti-Airborne or Heli-borne Operations (Contact very likely).			Mobile Tasks such as Escorts, or Nuclear and Chemical Reconnaissance. (Contact less likely)			Includes receiving orders, moving to hides, assembly areas or OPs, rest, radio watch, sentry duties servicing and routine replenishment.	
		Includes some or all of the points listed in column (c) and probing forward using various movement drills and looping round enemy positions.			Includes assembly areas or OPs, rest, radio watch, sentry duties servicing and routine replenishment.			Includes receiving orders, moving to hides, assembly areas or OPs, rest, radio watch, sentry duties servicing and routine replenishment.	
Weighting given to Function									
(a)	(b)	(c)	(d)	(e)	(f)	(g)			
1 Weapons									
2 Comms									
3 Agility									
4 Vision									
5 Supply									
6 Weighting of Activity									

41.

Notes. 1. Fill in the headings above the table.

2. Consider columns (c), (d), (e) and (f) separately. Complete Serials 1-5 by giving a figure for each function to show the relative importance you attach to it in carrying out the activity. The total of the weightings must be 10. See the completed example.

3. Consider the four activities in columns (c), (d), (e), and (f) together. Complete Serial 6 by giving a figure in each column to show the relative importance you attach to each activity. The total of your figures in the three columns must be 10. See the example.

4. Leave column (g) blank.

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RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF AN APC DURING OPERATIONS  
(FV432 IN 'STRAIGHT' APC ROLE)

1. Rank ..... 3. Experience .....  
2. Appointment ..... 4. Place .....

Activity	Serial/Function					
	1 Carried Section	2 Supply	3 Communi- cations	4 Agility	5 Vision	6 Weighting of Activity
(a) <u>Carriage of Infantry Section</u> Includes carriage to and from dismounted positions, and also may include reconnaissance of positions, routes and hides, movement to battle positions, observation, target acquisition, contact reports, fire and manoeuvre and battle replenishment.						
(b) <u>Waiting for Battle to Begin.</u> Includes receiving orders, moving to hides or assembly areas, rest, radio watch, sentry duties, servicing and routine replenishment.						
(c) Sum						

Notes. 1. Fill in the headings above the table.

2. Consider rows (a) and (b) separately. Complete Serials 1-5 by giving a figure for each function to show the relative importance you attach to it (higher importance-higher number) in carrying out the activity. Regard Serial 1 as comprising the 'Weapon' of the APC. The total weightings must be 10.

3. Consider the two activities in rows (a) and (b) together. Complete Serial 6 by giving a figure in each row to show the relative importance you attach to each activity. The total of your figures in the two rows must be 10. See the example.

4. Leave row (c) blank.

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RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF AN APC DURING OPERATIONS

FV432 WITH TURRET MOUNTED WEAPON

1. Rank ..... 3. Experience .....  
2. Appointment ..... 4. Place .....

Activity	Serial/Function						
	1 Carried Section	2 Vehicle Mounted Weapons	3 Communi- cations	4 Agility	5 Vision	6 Supply	7 Weighting of Activity
(a) <u>Carriage of Infantry Section</u> Includes carriage to and from dismounted positions, and also may include reconnaissance of positions, routes and hides, movement to battle positions, observation, target acquisition, contact reports, fire and manoeuvre and battle replenishment.							
(b) <u>Engagement of Enemy Light AFV's</u> . May include all the points listed in row (a) and also fire support for infantry on foot or in other APC's, assault of enemy defended positions, close protection of infantry on the move or in defended positions.							
(c) <u>Waiting for Battle to Begin</u> . Includes receiving orders, moving to hides or assembly areas, rest, radio watch, sentry duties, servicing and routine replenishment.							
(d) <u>Sum</u>							

Notes. 1. Fill in the headings above the table.  
2. Consider rows (a), (b) and (c) separately. Complete Serials 1-6 by giving a figure for each function to show the relative importance you attach to it (higher importance-higher number) in carrying out the activity. Regard Serials 1 and 2 as comprising the 'Weapon' of the APC. The total weightings must be 10. See the completed example.  
3. Consider the three activities in rows (a), (b) and (c) together. Complete Serial 7 by giving a figure in each row to show the relative importance you attach to each activity. The total of your figures in the three rows must be 10. See the example.  
4. Leave row (d) blank.

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## ANNEX D

## ii. TABLES OF RELATIVE IMPORTANCE

RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF A TANK  
IN A TROOP DURING OPERATIONS

## Weighting of Importance

Tanks 9 Maj 10 Capt 7 Lt 8 2/Lt 3 Sgt

No.	Rank	Activity			Variable (Function)				
		Destru- ction of Enemy Armour	Close Combat with Infantry	Waiting for Battle to begin	Weapons	Communi- cations	Agility	Vision	Supply
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
1	Maj	5	2	3	0.36	0.14	0.17	0.17	0.16
2	"	5	3	2	0.26	0.29	0.10	0.21	0.14
3	"	6	3	1	0.43	0.26	0.09	0.10	0.12
4	"	5	3	2	0.28	0.12	0.20	0.28	0.12
5	"	5	3	2	0.37	0.22	0.16	0.13	0.12
6	"	6	3	1	0.28	0.24	0.16	0.19	0.13
7	"	6	3	1	0.33	0.17	0.10	0.28	0.12
8	"	3	2	5	0.30	0.22	0.10	0.15	0.23
9	"	4	4	2	0.28	0.16	0.16	0.22	0.18
10	Capt	5	3	2	0.35	0.27	0.16	0.16	0.06
11	"	5	4	1	0.26	0.25	0.13	0.29	0.07
12	"	5	4	1	0.29	0.185	0.25	0.17	0.105
13	"	5	3	2	0.28	0.27	0.12	0.21	0.12
14	"	6	3	1	0.34	0.31	0.06	0.25	0.04
15	"	5	4	1	0.27	0.26	0.10	0.20	0.17
16	"	4	1	5	0.30	0.11	0.11	0.20	0.28
17	"	5	4	1	0.37	0.25	0.18	0.11	0.09
18	"	5	4	1	0.29	0.24	0.16	0.19	0.12
19	"	3	4	3	0.28	0.20	0.16	0.17	0.19
20	Lt	6	3	1	0.35	0.30	0.09	0.15	0.11
21	"	5	3	2	0.28	0.17	0.20	0.25	0.10
22	"	5	2	3	0.29	0.27	0.12	0.16	0.16
23	"	3	2	5	0.18	0.24	0.17	0.26	0.15
24	"	5	3	2	0.29	0.27	0.11	0.19	0.14
25	"	5	3	2	0.18	0.18	0.25	0.16	0.23
26	"	5	3	2	0.28	0.26	0.12	0.20	0.14
27	2/Lt	5	2	3	0.25	0.22	0.20	0.17	0.16
28	"	3	4	3	0.27	0.23	0.13	0.21	0.16
29	"	4	3	3	0.35	0.37	0.06	0.07	0.15
30	"	5	4	1	0.23	0.28	0.26	0.10	0.13
31	"	5	3	2	0.25	0.23	0.13	0.17	0.22
32	"	4	2	4	0.22	0.30	0.12	0.18	0.18
33	"	5	3	2	0.26	0.23	0.10	0.23	0.18
34	"	5	2	3	0.28	0.22	0.12	0.22	0.16
35	Sgt	4	3	3	0.17	0.29	0.24	0.13	0.17
36	"	3	4	3	0.31	0.22	0.16	0.15	0.16
37	"	3	4	3	0.16	0.37	0.14	0.10	0.23

ii. TABLES OF RELATIVE IMPORTANCE

ANNEX D

RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF A TANK  
IN A TROOP DURING OPERATIONS

Ranking of Importance

Tanks 9 Maj 10 Capt 7 Lt 8 2/Lt 3 Sgt

No.	Rank	Activity			Variable (Function)				
		Destru- ction of Enemy Armour	Close Combat with Infantry	Waiting for Battle to begin	Weapons	Communi- cations	Agility	Vision	Supply
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
1	Maj	1	3	2	1	5	2.5	2.5	4
2	"	1	2	3	2	1	5	3	4
3	"	1	2	3	1	2	5	4	3
4	"	1	2	3	1.5	4.5	3	1.5	4.5
5	"	1	2	3	1	2	3	4	5
6	"	1	2	3	1	2	4	3	5
7	"	1	2	3	1	3	5	2	4
8	"	2	3	1	1	3	5	4	2
9	"	1.5	1.5	3	1	4.5	4.5	2	3
10	Capt	1	2	3	1	2	3.5	3.5	5
11	"	1	2	3	2	3	4	1	5
12	"	1	2	3	1	3	2	4	5
13	"	1	2	3	1	2	4.5	3	4.5
14	"	1	2	3	1	2	4	3	5
15	"	1	2	3	1	2	5	3	4
16	"	2	3	1	1	4.5	4.5	3	2
17	"	1	2	3	1	2	3	4	5
18	"	1	2	3	1	2	4	3	5
19	"	2.5	1	2.5	1	2	5	4	3
20	Lt	1	2	3	1	2	5	3	4
21	"	1	2	3	1	4	3	2	5
22	"	1	3	2	1	2	5	3.5	3.5
23	"	2	3	1	3	2	4	1	5
24	"	1	2	3	1	2	5	3	4
25	"	1	2	3	3.5	3.5	1	5	2
26	"	1	2	3	1	2	5	3	4
27	2/Lt	1	3	2	1	2	3	4	5
28	"	2.5	1	2.5	1	2	5	3	4
29	"	1	2.5	2.5	2	1	5	4	3
30	"	1	2	3	3	1	2	5	4
31	"	1	2	3	1	2	5	4	3
32	"	1.5	3	1.5	2	1	5	3.5	3.5
33	"	1	2	3	1	2.5	5	2.5	4
34	"	1	3	2	1	2.5	5	2.5	4
35	Sgt	1	2.5	2.5	3.5	1	2	5	3.5
36	"	2.5	1	2.5	1	2	3.5	5	3.5
37	"	2.5	1	2.5	3	1	4	5	2

ii. TABLES OF RELATIVE IMPORTANCE

ANNEX D

RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF AN MICV  
DURING OPERATIONS

Weighting of Importance

MICV 3 Majors 6 Captains

No.	Rank	Activity			Variable (Function)					
		Carriage of Infantry Section	Engagement of Enemy Light AFV's	Waiting for Battle to Begin	Section Carried	Weapons	Communications	Agility	Vision	Supply
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
1	Maj	4	3	3	0.13	0.26	0.21	0.17	0.13	0.10
2	"	5	3	2	0.134	0.121	0.225	0.275	0.195	0.05
3	"	6	1	3	0.065	0.09	0.28	0.335	0.10	0.13
4	Capt	4	3	3	0.13	0.16	0.20	0.21	0.14	0.16
5	"	5	4	1	0.05	0.185	0.265	0.245	0.11	0.145
6	"	5	2	3	0.09	0.12	0.30	0.205	0.11	0.175
7	"	6	1	3	0.13	0.125	0.23	0.215	0.10	0.20
8	"	3	4	3	0.10	0.18	0.245	0.20	0.15	0.125
9	"	5	3	2	0.27	0.18	0.19	0.15	0.12	0.09

Ranking of Importance

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
1	Maj	1	2.5	2.5	4.5	1	2	3	4.5	6
2	"	1	2	3	4	5	2	1	3	6
3	"	1	3	2	6	5	2	1	4	3
4	Capt	1	2.5	2.5	6	3.5	2	1	5	3.5
5	"	1	2	3	6	3	1	2	5	4
6	"	1	3	2	6	4	1	2	5	3
7	"	1	3	2	4	5	1	2	6	3
8	"	2.5	1	2.5	6	3	1	2	4	5
9	"	1	2	3	1	3	2	4	5	6

ANNEX D

RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF A RECONNAISSANCE VEHICLE IN A TROOP DURING OPERATIONS

i. TABLES OF RELATIVE IMPORTANCE

Weighting of Importance

Reconnaissance 6 Maj 6 Capt 8 Lt 4 2/Lt 1 Sgt

No.	Rank	Activity				Variable (Function)				
		Stealthy Observations and Reporting Delay	Mobile Advance to Contact, Pursuit	Mobile, Escorts, NBC Recce.	Waiting for Operations to Begin	Weapons	Communications	Agility	Vision	Supply
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
1	Maj	4	4	1	1	0.19	0.33	0.20	0.15	0.13
2	"	5	3	1	1	0.20	0.39	0.19	0.12	0.10
3	"	4	2	3	1	0.16	0.28	0.17	0.21	0.18
4	"	1	2	3	4	0.14	0.28	0.21	0.24	0.13
5	"	4	2	1	3	0.12	0.38	0.16	0.17	0.17
6	"	5	2	2	1	0.19	0.38	0.15	0.18	0.10
7	Capt	4	3	2	1	0.18	0.30	0.17	0.21	0.14
8	"	4	3	2	1	0.27	0.30	0.31	0.07	0.05
9	"	4	3	0	3	0.13	0.34	0.23	0.27	0.03
10	"	4	2	3	1	0.19	0.28	0.21	0.17	0.15
11	"	4	3	1	2	0.23	0.27	0.18	0.20	0.12
12	"	4	4	1	1	0.16	0.27	0.26	0.19	0.12
13	Lt	5	3	1	1	0.22	0.26	0.29	0.21	0.02
14	"	4	3	1	2	0.21	0.27	0.32	0.10	0.10
15	"	4	3	2	1	0.22	0.30	0.18	0.17	0.13
16	"	5	4	1	0	0.20	0.30	0.24	0.16	0.10
17	"	1	2	4	3	0.13	0.41	0.13	0.23	0.10
18	"	4	3	1	2	0.15	0.27	0.23	0.23	0.12
19	"	4	2	1	3	0.19	0.32	0.16	0.19	0.14
20	"	5	3	1	1	0.18	0.31	0.15	0.26	0.10
21	2/Lt	5	2	2	1	0.14	0.30	0.17	0.24	0.15
22	"	3	3	2	2	0.19	0.27	0.20	0.14	0.20
23	"	6	1	1	2	0.19	0.42	0.13	0.15	0.11
24	"	4	2	1	3	0.18	0.31	0.19	0.19	0.13
25	Sgt	4	2	3	1	0.12	0.33	0.16	0.20	0.19

ANNEX D

RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF A RECONNAISSANCE VEHICLE IN A TROOP DURING OPERATIONS

ii. TABLES OF RELATIVE IMPORTANCE

Ranking of Importance

Reconnaissance 6 Maj 6 Capt 8 Lt 4 2/Lt 1 Sgt

No.	Rank	Activity				Variable (Function)				
		Stealthy Observations and Reporting Delay	Mobile Advance to Contact, Pursuit	Mobile, Escorts, NBC Recce.	Waiting for Operations to Begin	Weapons	Communications	Agility	Vision	Supply
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
1	Maj	1.5	1.5	3.5	3.5	3	1	2	4	5
2	"	1	2	3.5	3.5	2	1	3	4	5
3	"	1	3	2	4	5	1	4	2	3
4	"	4	3	2	1	4	1	3	2	5
5	"	1	3	4	2	5	1	4	2.5	2.5
6	"	1	2.5	2.5	4	2	1	4	3	5
7	Capt	1	2	3	4	3	1	4	2	5
8	"	1	2	3	4	3	2	1	4	5
9	"	1	2.5	4	2.5	4	1	3	2	5
10	"	1	3	2	4	3	1	2	4	5
11	"	1	2	4	3	2	1	4	3	5
12	"	1.5	1.5	3.5	3.5	4	1	2	3	5
13	Lt	1	2	3.5	3.5	3	2	1	4	5
14	"	1	2	4	3	3	2	1	4.5	4.5
15	"	1	2	3	4	2	1	3	4	5
16	"	1	2	3	4	3	1	2	4	5
17	"	4	3	1	2	3.5	1	3.5	2	5
18	"	1	2	4	3	4	1	2.5	2.5	5
19	"	1	3	4	2	2.5	1	4	2.5	5
20	"	1	2	3.5	3.5	3	1	4	2	5
21	2/Lt	1	2.5	2.5	4	5	1	3	2	4
22	"	1.5	1.5	3.5	3.5	4	1	2.5	5	2.5
23	"	1	3.5	3.5	2	2	1	4	3	5
24	"	1	3	4	2	4	1	2.5	2.5	5
25	Sgt	1	3	2	4	5	1	4	2	3

## ANNEX D

## ii. TABLES OF RELATIVE IMPORTANCE

## RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF AN APC IN A TROOP DURING OPERATIONS

## (FV432 IN STRAIGHT APC ROLE) (APC(SR))

## Weighting of Importance

1 Col 6 Maj 7 Capt

No.	Rank	Activity		Variable (Function)				
		Carr. of Inf. Sec.	Waiting for Battle to begin	Carried Section	Supply	Communications	Agility	Vision
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1	Col	6	4	0.30	0.14	0.30	0.10	0.16
2	Maj	6	4	0.30	0.14	0.20	0.16	0.20
3	"	6	4	0.36	0.10	0.24	0.10	0.20
4	"	7	3	0.47	0.00	0.30	0.20	0.03
5	"	9	1	0.30	0.11	0.20	0.29	0.10
6	"	6	4	0.38	0.15	0.32	0.04	0.11
7	"	6	4	0.36	0.14	0.24	0.16	0.10
8	Capt	7	3	0.40	0.10	0.23	0.10	0.17
9	"	7	3	0.40	0.13	0.30	0.17	0.00
10	"	6	4	0.30	0.10	0.24	0.16	0.20
11	"	6	4	0.30	0.14	0.24	0.16	0.16
12	"	7	3	0.31	0.14	0.21	0.17	0.17
13	"	6	4	0.36	0.10	0.24	0.10	0.20
14	"	6	4	0.33	0.12	0.25	0.14	0.16

## Ran Ranking of Importance

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1	Col	1	2	1.5	4	1.5	5	3
2	Maj	1	2	1	5	2.5	4	2.5
3	"	1	2	1	4.5	2	4.5	3
4	"	1	2	1	5	2	3	4
5	"	1	2	1	4	3	2	5
6	"	1	2	1	3	2	5	4
7	"	1	2	1	4	2	3	5
8	"	1	2	1	4.5	2	4.5	3
9	"	1	2	1	4	2	3	5
10	"	1	2	1	5	2	4	3
11	"	1	2	1	5	2	3.5	3.5
12	"	1	2	1	5	2	3.5	3.5
13	"	1	2	1	4.5	2	4.5	3
14	"	1	2	1	5	2	4	3

ANNEX D

ii. TABLES OF RELATIVE IMPORTANCE

RELATIVE IMPORTANCE OF VARIOUS FUNCTIONS AND ACTIVITIES OF AN APC IN A TROOP DURING OPERATIONS

(FV432 WITH TURRET MOUNTED WEAPON) (APC(TMW))

Weighting of Importance

1 Col 6 Maj 7 Capt

No.	Rank	Activity			Variable (Function)					
		Carr. of Inf. Sec.	Eng. of En. Light AFV's	Waiting for Battle to begin	Carried Section	Vehicle Mounted Weapons	Communications	Agility	Vision	Supply
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
1	Col	3	4	3	0.12	0.24	0.30	0.10	0.14	0.10
2	Maj	4	2	4	0.26	0.14	0.16	0.14	0.20	0.10
3	"	5	3	2	0.16	0.19	0.30	0.13	0.13	0.09
4	"	5	3	2	0.37	0.29	0.22	0.07	0.05	0.00
5	"	5	4	1	0.25	0.17	0.19	0.27	0.10	0.02
6	"	5	3	2	0.21	0.11	0.30	0.11	0.17	0.10
7	"	5	3	2	0.24	0.24	0.20	0.18	0.10	0.04
8	Capt	4	4	2	0.22	0.22	0.22	0.14	0.14	0.06
9	"	5	4	1	0.18	0.27	0.26	0.14	0.08	0.07
10	"	4	4	2	0.20	0.22	0.22	0.14	0.14	0.08
11	"	4	4	2	0.16	0.18	0.26	0.14	0.18	0.08
12	"	4	4	2	0.18	0.30	0.12	0.12	0.24	0.04
13	"	4	4	2	0.14	0.22	0.30	0.14	0.14	0.06
14	"	3	5	2	0.10	0.19	0.16	0.23	0.22	0.10

Ranking of Importance

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
1	Col	2.5	1	2.5	4	2	1	5.5	3	5.5
2	Maj	1.5	3	1.5	1	4.5	3	4.5	2	6
3	"	1	2	3	3	2	1	4.5	4.5	6
4	"	1	2	3	1	2	3	4	5	6
5	"	1	2	3	2	4	3	1	5	6
6	"	1	2	3	2	4.5	1	4.5	3	6
7	"	1	2	3	1.5	1.5	3	4	5	6
8	Capt	1.5	1.5	3	2	2	2	4.5	4.5	6
9	"	1	2	3	3	1	2	4	5	6
10	"	1.5	1.5	3	3	1.5	1.5	4.5	4.5	6
11	"	1.5	1.5	3	4	2.5	1	5	2.5	6
12	"	1.5	1.5	3	3	1	4.5	4.5	2	6
13	"	1.5	1.5	3	4	2	1	4	4	6
14	"	2	1	3	5.5	3	4	1	2	5.5

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ANNEX D

iii. Method of Rank Correlation

The weightings of importance of the activities and functions have been ranked in order of importance. The extent of agreement may be estimated using rank correlation methods (ref. 7).

For  $m$  rows and  $n$  columns,  $S$  = Sum of squares of deviations of column sums from column means.

Some of the rankings may contain ties; for pairs  $t = 2$ , for triplets  $t = 3$ , etc., and

$$T' = (1/12) \sum_t (t^3 - t) \quad \dots (1)$$

The coefficient of concordance may be defined as  $W$  where

$$W = S / ((1/12)m^2(n^3 - n) - m \sum T'), \quad \dots (2)$$

the summation  $\sum$  taking place over the various rankings.

The distribution of  $W$  has been worked out for lower values of  $m$  and  $n$ ;  $n = 3$ ,  $m = 2$  to 10;  $n = 4$ ,  $m = 2$  to 6;  $n = 5$ ,  $m = 3$ . These form the basis of Appendix Tables 5 in ref. 7. For higher values, other than those in Tables 5, ref. 7, an approximation may be based on the Fisher's  $z$ -distribution. In this case

$$z = (1/2) \log_e ((m-1)W/(1-W)) \quad \dots (3)$$

$$v_1 = n - 1 - 2/m \quad \dots (4)$$

$$v_2 = (m - 1)v_1 \quad \dots (5)$$

For degree of freedom  $v_1$  and  $v_2$ ,  $z$  may be tested in tables of Fisher's distribution.

Appendix Table 6 of ref. 7 gives the corresponding values of  $S$  to those of  $z$  at probability levels of 5% and 1% for various values of  $m$  from 3 to 20 and for  $n$  from 3 to 7.

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ANNEX D

iv. Method for Analysis of Variance

An analysis of variance was performed on the weightings of importance of the activities and of the variables (functions). The following model was used:-

$$y_{nm} = \mu + d_n + \sigma \epsilon_{nm}$$

$M$  = number of rows,  $m = 1$  to  $M$

$N$  = number of columns,  $n = 1$  to  $N$

$\mu$  = overall mean

$d_n$  = correction to mean for  $n$ th function

$\epsilon_{nm}$  = random variation

$$y_{n.} = \frac{\sum y_{nm}}{M} ; \quad y_{.m} = \frac{\sum y_{nm}}{N} ; \quad y.. = \frac{\sum \sum y_{nm}}{NM}$$

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Mean Square Ratio
Between Columns	$\sum (y_{n.} - y..)^2$ ( = C)	$N - 1$	$S_d^2$ ( = $C/(N-1)$ )	$S_d^2/S^2$ ( = $F_{N-1, N(M-1)}$ if $H_0$ true, otherwise larger)
Within Columns	$\sum (y_{nm} - y_{n.})^2$ ( = B)	$N(M - 1)$	$S^2$ ( = $B/N(M-1)$ )	
Total	$\sum (y_{nm} - y..)^2$ ( = A)	$NM - 1$		

$H_0 : d_1 = d_2 = \dots = d_n = 0$ . Test by one-tail F test.

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ANNEX D

v. Rank Correlation

Analyses have been performed on the results from all the replies for each type of AFV. These are shown below:-

AFV	TANKS	MICV	RECCE	APC(SR)*	APC(TMW)*
Nos.	37	9	25	14	14
<b>Activities</b>					
S	1255.5	85.5	1454	98	228.5
z	1.761	-	1.571	-	-
v <sub>1</sub>	1.9	-	2.9	-	-
v <sub>2</sub>	70	-	70	-	-
x	0.8025	85.5	0.7086	-	117.8
p(S>x)%	-	0.6	-	-	1
p(z>x)%	1	-	1	-	-
(v <sub>1</sub> , v <sub>2</sub> )	(2,60)	-	(3,60)	Satis	-
<b>Variables</b>					
S	6708.5	797.5	3854.5	1550	1871.5
z	1.791	-	1.843	-	-
v <sub>1</sub>	3.9	-	3.9	-	-
v <sub>2</sub>	142	-	94	-	-
x	0.6472	441	0.6472	442	221.4
p(S>x)%	-	1	-	1	1
p(z>x)%	1	-	1	-	-
(v <sub>1</sub> , v <sub>2</sub> )	(4,60)	-	(4,60)	-	-

This analysis shows significance at the 1% level. However, a similar analysis performed on the groups within the types of AFV shows that some of the replies can justifiably be rejected. The groups consisted of those replies from users of similar rank; for TANKS, numbers 35 to 37 were rejected, and for RECCE, numbers 1 to 6 were re-examined as one of the replies had been ranked initially instead of weighted:-

AFV	TANKS	RECCE			
Nos.	35-37	1-34	1-6	1-3, 5,6	1-3, 5-25
<b>Activities</b>					
S	4.5	1206	45.5	78.5	1619
z	-	1.857	-	-	1.759
v <sub>1</sub>	-	1.9	-	-	2.9
v <sub>2</sub>	-	64	-	-	67
x	4.5	0.8025	45.5	78.5	0.7086
p(S>x)%	60	-	7	1.5	-
p(z>x)%	-	1	-	-	1
(v <sub>1</sub> , v <sub>2</sub> )	-	(2,60)	-	-	(3,60)
<b>Variables</b>					
S	63.5	6192.5	213.5	138.5	3501.5
z	-	1.842	-	-	1.806
v <sub>1</sub>	-	3.9	-	-	3.9
v <sub>2</sub>	-	130	-	-	90
x	63.5	0.6472	176.1	142.8	0.6472
p(S>x)%	4.8	-	1	1	-
p(z>x)%	-	1	-	-	1
(v <sub>1</sub> , v <sub>2</sub> )	-	(4,60)	-	-	(4,60)

\* TMW Turret Mounted Weapon.

\* SR Straight APC Role.

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## ANNEX D

## ANALYSIS OF RESULTS

## vi. Analysis of Variance

This was performed on the following replies:-

TANKS, 1 to 34 APC in straight role 1 to 14  
MICV, 1 to 9 APC with turret mounted weapon 1 to 14  
RECCE, 1 to 3, 5 to 25

The mean square ratio ( $S_d^2/S^2$ ) was tested using a one-tail F test. Results are as follows:-

No. of columns = N

No. of rows = M

$$v_1 = N - 1$$

$$v_2 = N(M - 1)$$

AFV <u>Activities</u>	TANKS	MICV	RECCE	APC (SR)	APC (TMW)
N	3	3	4	2	2
M	34	9	24	14	14
v <sub>1</sub>	2	2	3	1	2
v <sub>2</sub>	99	24	92	26	39
S <sub>d</sub> <sup>2</sup> /S <sup>2</sup>	64.9	15.6	48.3	86.2	33.7
F	7.45	9.34	5.96	13.74	8.33
v <sub>1</sub> , v <sub>2</sub> , 0.1%					

## Variables

N	5	6	5	5	6
M	34	9	24	14	14
$v_1$	4	5	4	4	5
$v_2$	165	48	115	65	78
$Sd^2/s^2$	48.5	10.0	57.4	50.4	17.0
$F_{v_1, v_2, 0.1\%}$	4.8	5.13	4.98	5.22	4.62

As can be seen all are significant at 0.1% (or better).

## vii. Statistics

The mean weightings of importance of the activities and variables are presented below as fractions. Sample standard deviations and standard errors of the means are also shown.

x = mean weighting

s = sample standard deviation

$s(\bar{x})$  = standard error of the mean

$$s(x)\% = 100(s(x)/x)$$

AFV	Activity/Variable	$\bar{x}$	s	$s(\bar{x})$	$s(\bar{x})\%$
TANKS	<u>Activity</u>				
1 to 34	Destruction of Enemy Armour	0.48	0.084	0.014	3
	Close Combat in Conjunction				
	with Infantry	0.30	0.079	0.013	4
	Waiting for Battle to Begin	0.22	0.120	0.021	9
	<u>Variable</u>				
	Weapons	0.29	0.053	0.009	3
	Communications	0.23	0.056	0.010	4
	Agility	0.14	0.051	0.009	6
	Vision	0.19	0.053	0.009	5
	Supply	0.15	0.050	0.009	6

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ANALYSIS OF RESULTS

	Activity/Variable	$\bar{x}$	s	$s(\bar{x})$	$s(\bar{x})\%$
AFV					
MICV	<u>Activity</u>				
1 to 9	Carriage of Infantry Section	0.48	0.097	0.032	7
	Engagement of Enemy Light AFV's	0.27	0.112	0.037	14
	Waiting for Battle to Begin	0.26	0.073	0.024	9
	<u>Variable</u>				
	Carried Section	0.12	0.063	0.021	17
	Weapons	0.16	0.051	0.017	11
	Communications	0.24	0.037	0.012	5
	Agility	0.22	0.056	0.019	8
	Vision	0.13	0.030	0.010	8
	Supply	0.13	0.046	0.015	12
RECCE	<u>Activity</u>				
1 to 3,	Stealthy Observation and				
5 to 25	Reporting, Delay	0.42	0.092	0.019	4
	Mobile, Advance to Contact,				
	Pursuit	0.27	0.076	0.016	6
	Mobile, Escorts, NBC Recce	0.16	0.088	0.018	11
	Waiting for Battle to Begin	0.16	0.088	0.018	11
	<u>Variable</u>				
	Weapons	0.18	0.037	0.008	4
	Communications	0.32	0.048	0.010	3
	Agility	0.20	0.053	0.011	5
	Vision	0.18	0.048	0.010	5
	Supply	0.12	0.045	0.009	8
APC	<u>Activity</u>				
IN STRAIGHT	Carriage of Infantry Section	0.65	0.086	0.023	4
APC ROLE	Waiting for Battle to Begin	0.35	0.086	0.023	7
1 to 14	<u>Variable</u>				
	Carried Section	0.35	0.052	0.014	4
	Supply	0.12	0.038	0.010	9
	Communications	0.25	0.039	0.010	4
	Agility	0.15	0.059	0.016	11
	Vision	0.14	0.064	0.017	12
APC	<u>Activity</u>				
WITH TURRET	Carriage of Infantry Section	0.43	0.073	0.019	5
MOUNTED	Engagement of Enemy Light AFV's	0.36	0.074	0.020	5
WEAPON	Waiting for Battle to Begin	0.21	0.073	0.020	9
1 to 14	<u>Variable</u>				
	Carried Section	0.20	0.069	0.018	9
	Vehicle Mounted Weapon	0.21	0.054	0.015	7
	Communications	0.23	0.060	0.016	7
	Agility	0.15	0.051	0.014	9
	Vision	0.15	0.054	0.014	10
	Supply	0.07	0.032	0.009	13

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ANNEX D

viii. Weightings of Importance

The following are the weightings of importance of the activities and the variables in decreasing order of importance.

TANKS

Activities

Destruction of Enemy Armour	0.48 ± 0.01
Close Combat in Conjunction with Infantry	0.30 ± 0.01
Waiting for Battle to Begin	0.22 ± 0.02

Variables

Weapons	0.29 ± 0.01
Communications	0.23 ± 0.01
Vision	0.19 ± 0.01
Supply	0.15 ± 0.01
Agility	0.14 ± 0.01

MICV

Activities

Carriage of Infantry Section	0.48 ± 0.03
Engagement of Enemy Light AFV's	0.27 ± 0.04
Waiting for Battle to Begin	0.26 ± 0.02

Variables

Communications	0.24 ± 0.01
Agility	0.22 ± 0.02
Weapons	0.16 ± 0.02
Supply	0.13 ± 0.02
Vision	0.13 ± 0.01
Section Carried	0.12 ± 0.02

RECCE

Activities

Stealthy Observation and Reporting, Imposing Delay	0.42 ± 0.02
Mobile Duties such as Advance to Contact, Pursuit	0.27 ± 0.02
Mobile Duties such as Escorts, NBC Recce	0.16 ± 0.02
Waiting for Battle to Begin	0.16 ± 0.02

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Variables

Communications	0.32 ± 0.01
Agility	0.20 ± 0.01
Vision	0.18 ± 0.01
Weapons	0.18 ± 0.01
Supply	0.12 ± 0.01

APC IN STRAIGHT APC ROLE

Activities

Carriage of Infantry Section	0.65 ± 0.02
Waiting for Battle to Begin	0.35 ± 0.02

Variables

Carried Section	0.35 ± 0.01
Communications	0.25 ± 0.01
Agility	0.15 ± 0.02
Vision	0.14 ± 0.02
Supply	0.12 ± 0.01

APC WITH TURRET MOUNTED WEAPON

Activities

Carriage of Infantry Section	0.43 ± 0.02
Engagement of Enemy Light AFV's	0.36 ± 0.02
Waiting for Battle to Begin	0.21 ± 0.02

Variables

Communications	0.23 ± 0.02
Vehicle Mounted Weapons	0.21 ± 0.02
Carried Section	0.20 ± 0.02
Agility	0.15 ± 0.01
Vision	0.15 ± 0.01
Supply	0.07 ± 0.01

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